yli130_Assignment4

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Question 1

In this problem, the total Production Capacity is 220, while the Monthly Demand is only 210. Since Production Capacity is larger than Monthly Demand, there are 2 ways to solve this problem. One is creating the dummy Warehouse for Warehouse 4; Making Production Capacity is <= in the formulation is the other method. I will list this 2 ways separately.

I use 3 ways to solve this problem since I found import lp file is not always the good way to show results.

Method 1

This way is to create dummy variable for Warehouse 4. I will put the formulation as follows.

```
/* objective function */
Min: 622 x11 + 614 x12 + 630 x13 + 641 x21 + 645 x22 + 649 x23;

/* Constraints */

/* Monthly Demand */
x11 + x21 = 80;
x12 + x22 = 60;
x13 + x23 = 70;
x14 + x24 = 10;

/* Production Capacity  */
x11 + x12 + x13 + x14 = 100;
x21 + X22 + X23 + x24 = 120;
```

```r
# import the library
library(lpSolveAPI)

# set Working Directory
setwd("C:/Users/yanxi/OneDrive - Kent State University/Desktop/Quantitative Management Modeling/Assignm

# read the lp file
Formulation_Q1_M1 <- read.lp('Assign 4-Q1.lp')

# solve the lp model
solve(Formulation_Q1_M1)
```

```
## [1] 0
```

```
# get the objective function value
get.objective(Formulation_Q1_M1)
```

```
## [1] 132790
```

```
# get the decision variables values
get.variables(Formulation_Q1_M1)
```

```
##  [1]  0 60 40 80  0 30  0 10 30  0
```

Method 2

```
/* objective function */
Min: 622 x11 + 614 x12 + 630 x13 + 641 x21 + 645 x22 + 649 x23;

/* Constraints */

/* Monthly Demand */
x11 + x21 = 80;
x12 + x22 = 60;
x13 + x23 = 70;

/* Production Capacity  */
x11 + x12 + x13  <= 100;
x21 + X22 + X23  <= 120;
```

```
# read lp file
Formulation_Q1_M2 <- read.lp('Assign 4-Q1-Method-2.lp')

# solve the lp model
solve(Formulation_Q1_M2)
```

```
## [1] 0
```

```
# get the objective function value
get.objective(Formulation_Q1_M2)
```

```
## [1] 132790
```

```
# get the decision variables values
get.variables(Formulation_Q1_M2)
```

```
## [1]  0 60 40 80  0 30  0  0
```

Method 3

```
# Create an LP model using make.lp, there are 6 decision variables.
lprec1 <- make.lp(0, 6)

# set the objective function, which is default to be minimized.
set.objfn(lprec1, c(622, 614, 630, 641, 645, 649))

# add constraints
add.constraint(lprec1, c(1, 0, 0, 1, 0, 0), "=", 80)
add.constraint(lprec1, c(0, 1, 0, 0, 1, 0), "=", 60)
add.constraint(lprec1, c(0, 0, 1, 0, 0, 1), "=", 70)
add.constraint(lprec1, c(1, 1, 1, 0, 0, 0), "<=", 100)
add.constraint(lprec1, c(0, 0, 0, 1, 1, 1), "<=", 120)

# show constraints & decision variables
lprec1
```

```
## Model name:
##              C1    C2    C3    C4    C5    C6
## Minimize    622   614   630   641   645   649
## R1            1     0     0     1     0     0   =   80
## R2            0     1     0     0     1     0   =   60
## R3            0     0     1     0     0     1   =   70
## R4            1     1     1     0     0     0  <=  100
## R5            0     0     0     1     1     1  <=  120
## Kind        Std   Std   Std   Std   Std   Std
## Type       Real  Real  Real  Real  Real  Real
## Upper       Inf   Inf   Inf   Inf   Inf   Inf
## Lower         0     0     0     0     0     0
```

```
# solve the lp model
solve(lprec1)
```

```
## [1] 0
```

```
# get the objective function value
get.objective(lprec1)
```

```
## [1] 132790
```

```
# get the decision variables values
get.variables(lprec1)
```

```
## [1]  0 60 40 80  0 30
```

For Question1, decision variables are 0, 60, 40, 80, 0, 30. Objective function value is 132790.

Question 1 Results

```
# create 4 column names to show results
Plant_Type <- c("Plant A", "Plant B")
Warehouse1 <- c(0, 80)
Warehouse2 <- c(60, 0)
Warehouse3 <- c(40, 30)

# data frame the 3 columns
Question_1_Results <- data.frame(Plant_Type, Warehouse1, Warehouse2, Warehouse3)

# Show Question 1 Results in data frame
Question_1_Results
```

```
##   Plant_Type Warehouse1 Warehouse2 Warehouse3
## 1    Plant A          0         60         40
## 2    Plant B         80          0         30
```

Question 2

```
For this question, there are 24 variables, I cannot import the lp file successfully,
                                                        just show the formualtion as follows.
```

```
/* objective function */
Min: 1.52 x14 + 1.6 x15 + 1.4 x16 + 1.7 x24 + 1.63 x25 + 1.55 x26 + 1.45 x34 + 1.57 x35 + 1.3 x36 +
5.15 x47 + 5.69 x48 + 6.13 x49 + 5.63 x410 + 5.8 x411 + 5.12 x57 + 5.47 x58 + 6.05 x59 + 6.12 x510 +
5.71 x511 + 5.32 x67 + 6.16 x68 + 6.25 x69 + 6.17 x610 + 5.87 x611;

/* Constraints */

/* Well Constraints */
x14 + x15 + x16 <= 93;
x24 + x25 + x26 <= 88;
x34 + x35 + x36 <= 95;

/* Intermediete Pump Notes Constraints */
x14 + x24 + x34 = x47 + x48 + x49 + x410 + x411;
x15 + x25 + x35 = x57 + x58 + x59 + x510 + x511;
x16 + x26 + x36 = x67 + x68 + x69 + x610 + x611;

/* Refineries Constraints  */
x47 + x57 + x67 = 30;
x48 + x58 + x68 = 57;
x49 + x59 + x69 = 48;
x410 + x510 + x610 = 91;
x411 + x511 + x611 = 48;
```

```
# Create LP model objects
lprec2 <- make.lp(11,24)
```

```
# set objective function

set.objfn(lprec2, c(1.52, 1.6, 1.4, 1.7, 1.63, 1.55, 1.45, 1.57, 1.3, 5.15, 5.69, 6.13,
                    5.63, 5.8, 5.12, 5.47, 6.05, 6.12, 5.71, 5.32, 6.16, 6.25, 6.17, 5.87))

# add constraints

# Well constraints
set.row(lprec2, 1, c(1,1,1), indices = c(1,2,3))
set.row(lprec2, 2, c(1,1,1), indices = c(4,5,6))
set.row(lprec2, 3, c(1,1,1), indices = c(7,8,9))

# Pump constraints
set.row(lprec2, 4, c(1,1,1,-1,-1,-1,-1,-1), indices = c(1,4,7,10,11,12,13,14))
set.row(lprec2, 5, c(1,1,1,-1,-1,-1,-1,-1), indices = c(2,5,8,15,16,17,18,19))
set.row(lprec2, 6, c(1,1,1,-1,-1,-1,-1,-1), indices = c(3,6,9,20,21,22,23,24))

# Refineries constraint
set.row(lprec2, 7, c(1,1,1), indices = c(10,15,20))
set.row(lprec2, 8, c(1,1,1), indices = c(11,16,21))
set.row(lprec2, 9, c(1,1,1), indices = c(12,17,22))
set.row(lprec2, 10, c(1,1,1), indices = c(13,18,23))
set.row(lprec2, 11, c(1,1,1), indices = c(14,19,24))

# set right hand side of constraint
rhs <- c(93, 88, 95, 0, 0, 0, 30, 57, 48, 91, 48)
set.rhs(lprec2, rhs)

# set constraint type
set.constr.type(lprec2, c("<=", "<=", "<=", "=", "=", "=", "=", "=", "=", "=", "="))

# show numbers of decision variables & constraints
lprec2
```

```
## Model name:
##   a linear program with 24 decision variables and 11 constraints
```

```
# solve the lp model
solve(lprec2)
```

```
## [1] 0
```

```
# get the objective function value
get.objective(lprec2)
```

```
## [1] 1963.82
```

```
# get 24 decision variables values
get.variables(lprec2)
```

```
##  [1] 93  0  0  0 86  0 28  0 67 30  0  0 91  0  0 57 29  0  0  0  0 19  0 48
```

For Question 2, decision variables values: x14=93, x15=0, x16=0, x24=0, x25=86, x26=0, x34=28, x35=0, x36=67, x47=30, x48=0, x49=0, x410=91, x411=0, x57=0, x58=57, x59=29, x510=0, x511=0, x67=0, x68=0, x69=19, x610=0, x611=48.

Objective function value = 1963.82

Quesion 2 Results

First is the Well, Pump table.

```
# create 3 column names to show results
Well_Type <- c("Well 1", "Well 2", "Well 3")
Pump_A <- c(93, 0, 0)
Pump_B <- c(0, 86, 0)
Pump_C <- c(28, 0, 67)

# create data frame
Question_2_1table <- data.frame(Well_Type, Pump_A, Pump_B, Pump_C)

# show the first table
Question_2_1table
```

```
##   Well_Type Pump_A Pump_B Pump_C
## 1    Well 1     93      0     28
## 2    Well 2      0     86      0
## 3    Well 3      0      0     67
```

Second is the Pump, Refineries table.

```
# create 6 columns to show results
Pump_Type <- c("Pump A", "Pump B", "Pump C")
R1 <- c(30, 0, 0)
R2 <- c(0, 57, 0)
R3 <- c(0, 29, 19)
R4 <- c(91, 0, 0)
R5 <- c(0, 0, 48)

# create data frame
Question_2_2table <- data.frame(Pump_Type, R1, R2, R3, R4, R5)

# show the second table
Question_2_2table
```

```
##   Pump_Type R1 R2 R3 R4 R5
## 1    Pump A 30  0  0 91  0
## 2    Pump B  0 57 29  0  0
## 3    Pump C  0  0 19  0 48
```